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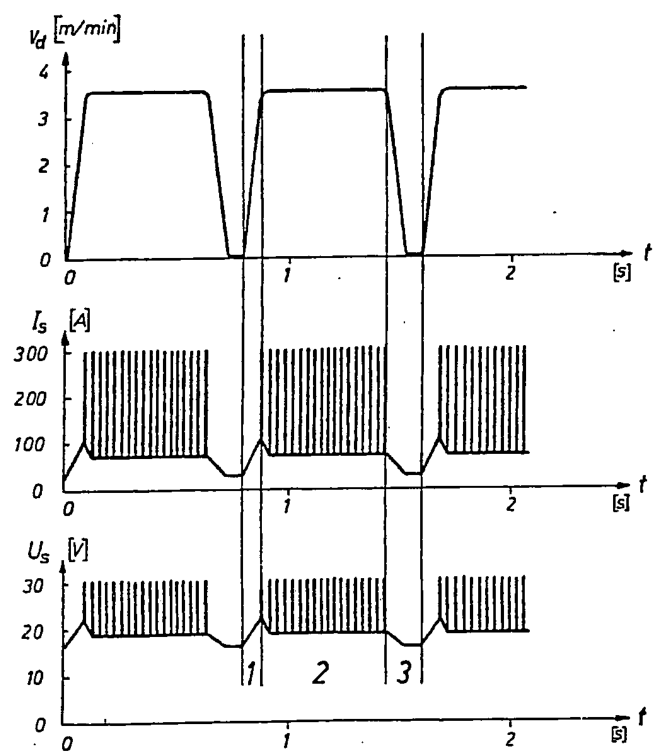
(71) Applicants: SCHWEISSINDUSTRIE OERLIKON BUHRLE A.G. BIRCHSTRASSE 230, ZURICH, SWITZERLAND
(72) Inventors: GERASSIMOS DRACOPOULOS, WALTER KUNZ
(74) Agents: MESSRS, J. A. KEMP & CO.

(54) METHOD OF AND APPARATUS FOR PULSED ARC WELDING WITH INTERMITTENT ELECTRODE WIRE ROD FEED

(57) The disclosed method is for MIG welding of high-alloyed steels by means of a pulsed arc by cyclically controlling the arc to produce a starting phase 1, a welding phase 2, and a cooling phase 3; wherein the feed speed V_d of the electrode wire in the direction of the weld pool is controlled synchronously with the starting phase and with the cooling phase respectively to increase to an upper value and to decrease to a lower value.

Also disclosed is an apparatus for practicing the above method, which comprises a circuit, driven by a frequency generator, which controls the time sequence of the starting phase, the welding phase, and the cooling phase in each cycle and operates a basic current circuit, a pulsing current circuit, and an electrode wire feed mechanism synchronously to one another. Specific time sequence and frequencies are disclosed.



Figur 1

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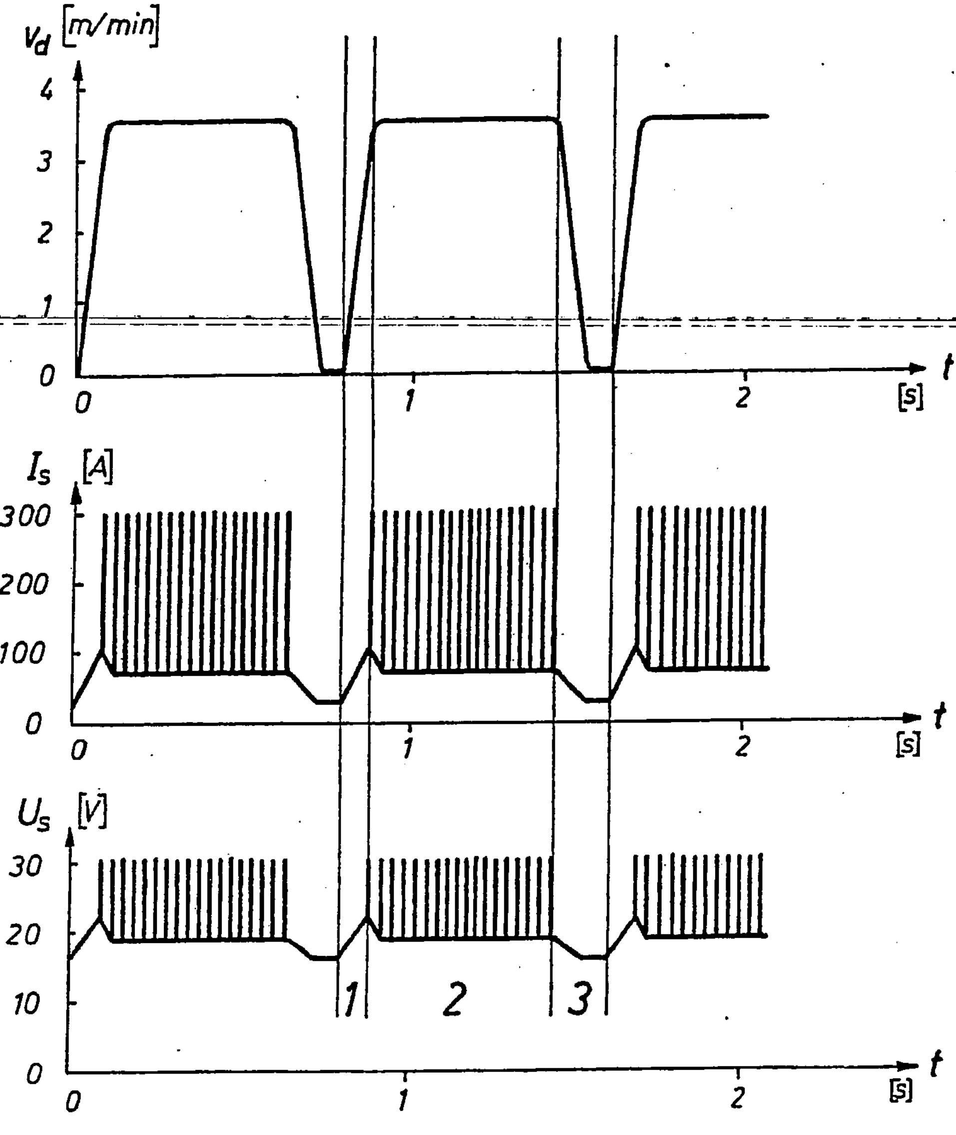

Figur 1

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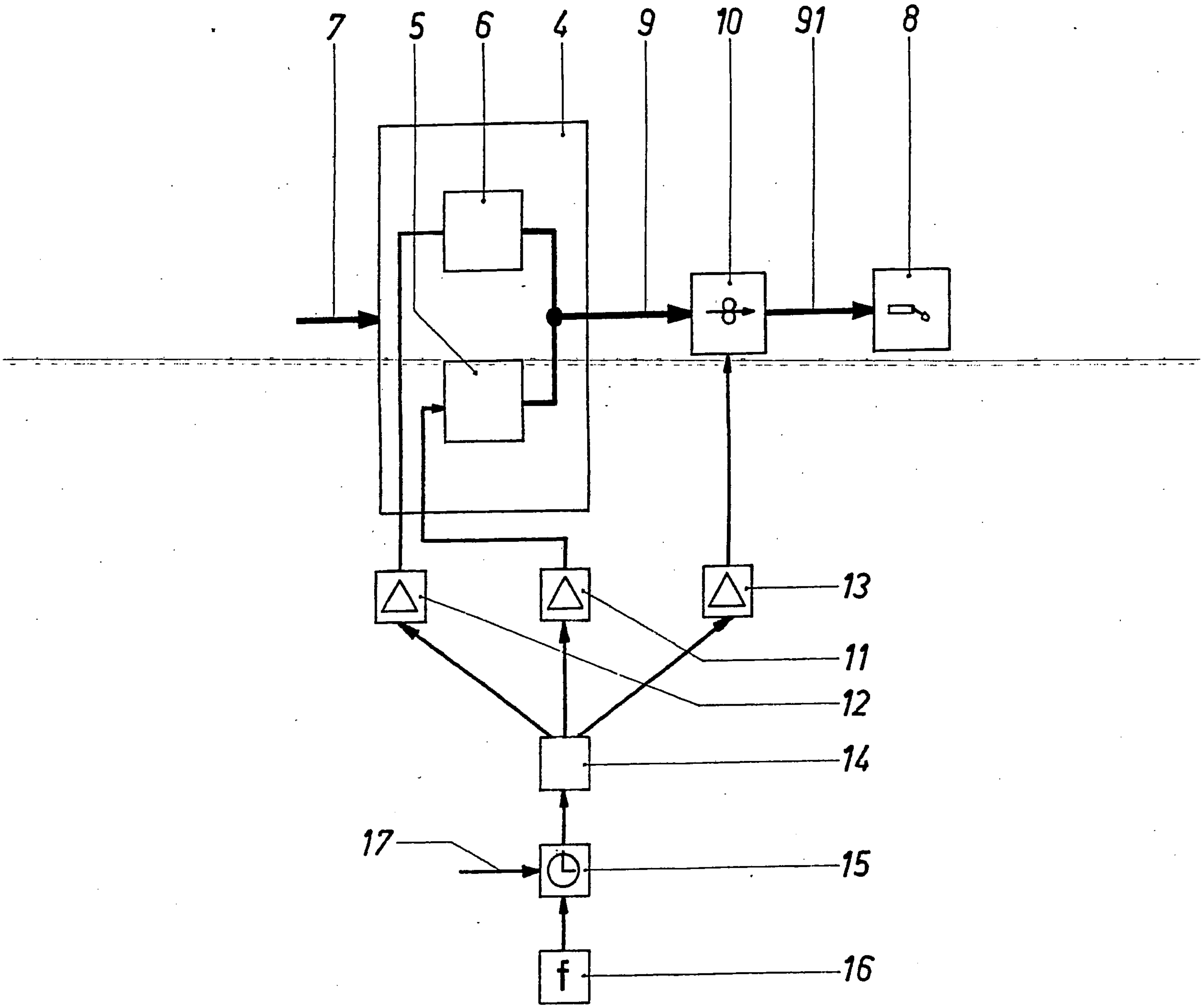

Figur 2

SPECIFICATION

METHOD OF AND APPARATUS FOR IMPULSE WELDING WITH INTERMITTENT ROD FEED

The invention relates to an MIG welding method of welding by means of a pulsed arc, as well as to an apparatus for performing such a method.

In the currently standard MIG (metal-inert gas) pulsed arc welding method, the arc operates on a relatively low basic average power by short intense power pulses, which leads to a forced detachment of fine drops from the wire electrode. Welding performed at such a low average power makes it possible to increase the ratio of electrode diameter to material thickness compared with MIG inert gas metal arc welding. This advantage is particularly utilized in thin-sheet welding. Forced drop detachment has also proved advantageous for fixed-position welding. The method and apparatus for performing this method is, for example described in detail in U.S. Patent 3,568,032. However, in for example, the vertical welding of a high-alloyed nickel chrome steel it is not sufficient to obtain a clean, uniform weld. The known poor thermal conductivity of this material leads to a localization of heat in the welding zone. The fluid weld pool is displaced downwards under the action of gravity and solidifies in the form of large drops, leading to a qualitatively unsatisfactory weld bead. The weld produced in this way is not really pressure-tight or vacuum-tight and has an unattractive surface.

According to a first aspect of the invention, there is provided a method of fixed-position welding high-alloyed steels by means of a pulsed arc, wherein the arc is cyclically controlled in a starting phase, a welding phase, and a cooling phase and the feed speed of the electrode in the direction of the weld pool is controlled synchronously with the starting phase and with the cooling phase to an upper threshold value and to a lower threshold value, respectively.

A second aspect of the invention provides apparatus for fixed-position welding of high-alloyed steels by means of a pulsed arc by use of a method wherein the arc is cyclically controlled in a starting phase, a welding phase, and a cooling phase and the feed speed of the electrode in the direction of the weld pool is controlled synchronously with the starting phase and with the cooling phase to an upper threshold value and to a lower threshold value, respectively, said apparatus comprising: a circuit controlled by a frequency generator, said circuit controlling the time sequence of the starting phase, the welding phase, and the cooling phase in each cycle and operating a basic current supply circuit, a pulsing current supply circuit, and a wire feed mechanism synchronously to one another.

The invention will be further described by way of example with reference to the accompanying drawings, wherein:—

Fig. 1 is a graphical representation of various parameters for practicing the welding method in accordance with a preferred embodiment of the present invention; and

Fig. 2 is a schematic block diagram of a circuit for a preferred embodiment of an apparatus in accordance with the present invention for practicing the welding method of Fig. 1.

The upper part of Fig. 1 shows the feed speed Vd in m/min (meters per minute) of the wire electrode in the direction of the weld pool. The central part of Fig. 1 shows the welding current Is in amperes. The lower part of Fig. 1 shows the welding voltage Us in volts. All three representations have equal time scales, the time t being plotted on the abscissas. Fig. 1 was recorded during welding by means of an oscillograph, of which the time-base rate is 50 mm/sec. (millimeters per second). Fig. 1 shows two complete cycles, each cycle comprising a starting phase 1, a welding phase 2 and a cooling phase 3. In order to better represent these conditions, the individual phases are shown delimited by continuous vertical lines. The welding method of Fig. 1 is realized with the apparatus of Fig. 2 which will be described in greater detail hereinafter.

The welding method of Fig. 1 will now be described. The arc is ignited by the operator contacting the material to be welded with the electrode in conventional manner. This is not shown in Fig. 1, because only the time period of fixed position welding is shown. The cyclic control now commences. During the starting phase 1, the average welding voltage is increased from approximately 16 V (volts) to approximately 22V, so that there is an increase in the average welding current from approximately 30 A to approximately 100 A. At the same time, the feed speed Vd of the welding rod in the direction of the weld pool is increased, synchronously with the average welding voltage, from 0 to an upper threshold value of 3.6 m/min (meters per minute). It is pointed out here that the arc is already burning prior to the start of the starting phase 1. Starting phase 1 is immediately followed by welding phase 2, while the feed speed Vd and the average welding voltage Us remain constant, which also leads to a constant average welding current Is. The welding voltage is formed by a basic voltage component and a pulsing voltage component, which can be seen in the lower part of Fig. 1. In the same way, welding current Is has a basic current component and a pulsing current component. The welding phase 2 is followed by the so-called cooling phase 3, in which the average welding voltage Us is reduced to a minimum threshold value of approximately 16 V while synchronously with this the feed speed Vd of the wire electrode is controlled to reduce to 0 m/min. The pulsing component of the welding voltage is no longer present. Only the basic voltage component is present. This means that only the basic current component of the welding current permits the further burning of the arc,

which is reduced to a minimum. As a result, the ionization of the arc column is maintained. This cooling phase 3 of one cycle is immediately followed by the starting phase 1 of the next cycle. The cycles are repeated with a frequency of 6—0.4 Hz (hertz), so that starting phase 1 and welding phase 2 last 280 ms (milliseconds) and 2,000 ms, respectively. The cooling phase lasts between 50 and 500 ms. It is, of course, possible to vary the above times within a still wider range, this depending on the individual conditions of the welding process.

The apparatus of Fig. 2 essentially comprises an MIG pulsing current supply 4 which contains a circuit 5 for the basic current component of welding current Is and a pulsing circuit 6 for the pulse-like component of welding current Is. The power supply from a power line and the supply of insert gas for the MIG pulsing current supply are indicated by arrow 7. The pulsing current supply 4 supplies torch 8 with the necessary welding current, as well as the requisite quantity of inert gas via the lines indicated by arrows 9 and 91. In practice, these lines are connected to the wire feed mechanism 10. The wire feed mechanism contains the wire welding electrode wound onto a drum with a length of approximately 100 m. The wire electrode is unwound from this drum and is transported by a special device to torch 8. Wire feed mechanism 10 contains a corresponding electrical, pneumatic, or hydraulic drive motor. Control 11 controls the basic current circuit 5. The pulsing circuit 6 is controlled by control 12. The wire feed mechanism 10 is controlled by control 13. The three controls 11, 12, 13 receive their control commands from control circuit 14, which controls the time sequence for each welding cycle. This welding cycle is represented in Fig. 1 as starting phase 1, welding phase 2, and cooling phase 3. The frequency generator 15 is connected in front of control circuit 14. The frequency generator supplies the predetermined frequency of the cyles by means of voltage signals to the control circuit 14. A manual input 16 is provided, and by means of this an operator can feed in the desired frequency of the cycles. However, this only applies in the case when the welding method according to the invention is performed manually. When this welding method is performed with an automatic welding apparatus, the manual input 16 is disconnected, and instead, the control device of the automatic welding apparatus is connected to the next input 17 of frequency generator 15. This control device supplies the desired frequency of the welding cycles to the frequency generator.

CLAIMS

1. A method of fixed-position welding high-alloyed steels by means of a pulsed arc, wherein the arc is cyclically controlled in a starting phase, a welding phase, and a cooling phase and the feed speed of the electrode in the direction of the weld pool is controlled synchronously with the starting phase and with the cooling phase to an upper threshold value and to a lower threshold value, respectively.

2. The method defined in Claim 1, wherein: during the starting phase the arc voltage and the electrode feed speed are increased to desired values so that the welding current rises to the desired value, during the welding phase they are controlled in a substantially constant manner, with the arc comprising during the welding phase a basic current component and a pulsing current component, and during the cooling phase the electrode feed speed is controlled to reduce to the lower threshold value, the pulsing component of the arc is switched off, and the basic current component of the arc is reduced to a minimum, so that the ionization of the arc column is uninterrupted.

3. Apparatus for fixed-position welding of high-alloyed steels by means of a pulsed arc by use of a method wherein the arc is cyclically controlled in a starting phase, a welding phase, and a cooling phase and the feed speed of the electrode in the direction of the weld pool is controlled synchronously with the starting phase and with the cooling phase to an upper threshold value and to a lower threshold value, respectively, said apparatus comprising: a circuit controlled by a frequency generator, said circuit controlling the time sequence of the starting phase, the welding phase, and the cooling phase in each cycle and operating a basic current supply circuit, a pulsing current supply circuit, and a wire feed mechanism synchronously to one another.

4. The apparatus defined in Claim 3 and wherein the arrangement is such that the time sequence of the starting phase and welding phase is in the range of from 280 to 2,000 milliseconds and the time sequence of the cooling phase is in the range of from 50 to 500 milliseconds.

5. The apparatus defined in Claim 3 and wherein the arrangement is such that the frequency of the welding cycles is in the range of from 3 to 0.4 hertz.

6. A method of welding substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

7. Welding apparatus constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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